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New sulfide compounds MeXMn1-XS (Me=3d metal) with the colossal magnetoresistance effect

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14. ABSTRACT

This report results from a contract tasking L.V. Kirensky Institute of Physics as follows: The project objective is to synthesize the new MeXMn1-XS (Me=3d-metal) sulfide compounds and to study the electrical, magnetic and magnetoresistive properties. Recently oxide compounds of manganese (LaMnO3-type) with perovskite structure have been intensively investigated. This interest is caused by the observation of colossal magnetoresistance (CMR) effect in these materials under the certain technological conditions and doping levels. The practical significance of this effect and the importance of CMR mechanism study stimulate the search of new compounds with CMR and the experimental study of transport properties of the materials with different structure. It is known that alpha - MnS manganese monosulfide, similar to LaMnO3, has the specific antiferromagnetic order with the characteristic ferromagnetic orientation of spins in alternating planes (111). As in LaMnO3-based systems, the transition from antiferromagnetic semiconductor state (AFM) to ferromagnetic metallic state (FM) is observed in cation-substituted MeXMn1-XS (Me=Fe, Cr) manganese sulfides with the change of doping concentration. This allows the realization of the CMR effect in compounds created on basis of alpha - MnS.

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The scientific report

Title of Proposal: New sulfide compounds $Me_XMn_{1-X}S$ (Me=3d metal) with the colossal magnetoresistance effect

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Task 6: Measurements of the electrical properties of the $Co_XMn_{1-X}S$ ($0 \le X \le 0.2$) polycrystalline samples.

The task 6 is posed for the sixth quarter is executed completely.

According to X-ray analysis data, $Co_XMn_{1-X}S$ samples with $0<X\le0.4$ have fcc lattice of NaCl-type, similar to α-MnS. With the increasing of cation substitution degree (X) the lattice parameter decreases linearly from ~ 5,222 Å (X = 0) to ~ 5,204 Å (X= 0.4), which evidences of solid solutions formation.

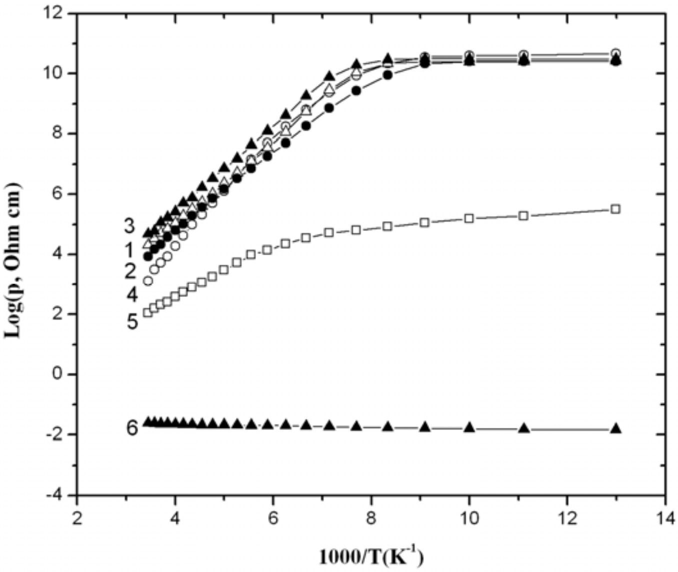

Fig.1 The temperature dependences of resistivity for $Co_XMn_{1-X}S$ samples with X: 0.05 (1); 0.1 (2); 0.15 (3); 0.2 (4); 0.3 (5); 0.4 (6)

The resistivity measurements for $Co_XMn_{1-X}S$ samples with the composition X=0.05 (1); 0.1 (2); 0.15 (3); 0.2 (4); 0.3 (5); 0.4 (6) are presented in fig.1. The behavior of temperature dependence of resistivity for small cobalt concentrations $0.05<X\le0.2$ is similar to lgρ(1/T) dependence for nonstoichiometric α – Mn_XS sulphides at the concentration change X [1].

For solid solutions with $X\le0.3$ the semiconductor type of conductivity with the resistivity change from 10^{10} Ohm cm (X=0) to 10^5 Ohm cm (X=0.3) at T = 80K. At T>500 K the intrinsic conductivity range is realized, analogously to α – MnS [2]. In the range of impurity conductivity (80 – 500 K) the activation energy changes from 0.01 eV to 0.30 eV with the further increase up to 0.42 eV at temperatures above 500 K.

Increase of Co concentration in sulphides from X~0.2 to X~0.4 leads to resistivity decrease of about 12 order of magnitude at 80 K (fig.1), which is typical for disordered systems with metal-insulator transition of Anderson type [3].

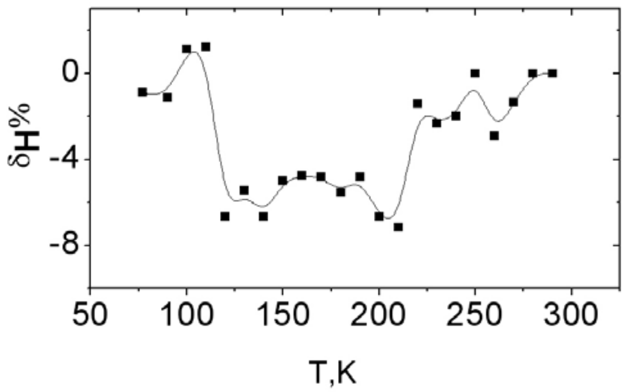

Fig.2 The temperature dependences of magnitoresistivity for $Co_{0.25}Mn_{0.75}S$ in magnetic field 15 kOe

The measurements of differential thermoelectric power temperature dependence showed that the samples with X≤0.3 posses of conductivity of hole type, while compounds with X=0.4 have electronic impurity conductivity, which should be caused by Co cations in MnS lattice.

The preliminary researches of the magnetoelectric properties of the samples $Co_{0.25}Mn_{0.75}S$ were carried out in the magnetic fields 5,10,15 kOe and the interval temperature of 80-350 K. It is revealed the negative colossal magnetoresistanse which grows with increase of the magnetic field and reaches the value of -8% at the magnetic field 15 kOe.

These compounds are considered as promising candidates for study of colossal magnetoresistance effect.

[1] L. I. Ryabinkina and G.V. Loseva Phys. Stat. Sol. (a) 80 (1983) k.179.

[2] H.Heikens, C.F. van Bruggen and C. Haas. J. Phys. Chem. Soc. 39 (1978) 833.

[3] N.F. Mott Metall- insulator transitions. M.: Nauka (1979) 344 p.